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EFFECT OF SITE-SPECIFIC TILLAGE ON DRAFT REQUIREMENTS AND COTTON YIELD

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Abstract

For those soils that require deep tillage to alleviate soil compaction, subsoiling can be an expensive and time-consuming tillage event. Alternative tillage methods are needed which conserve natural resources without sacrificing cotton yields. An experiment was conducted in a field in Southern Alabama prone to soil compaction for three years to evaluate whether the concept of site-specific tillage (tilling just deep enough to eliminate the hardpan layer) would reduce tillage energy requirements and/or reduce cotton yields. Average cotton yields over this three-year period showed that site-specific tillage produced yields equivalent to those produced by the uniform deep tillage treatment while requiring 27% less tillage power.

Introduction

Soil compaction may limit crop yields throughout much of the nation, but is particularly acute in the Southeastern U.S. In this region's Coastal Plains soils, a naturally occurring root-impeding layer restricts root growth and prevents crop roots from obtaining necessary moisture during temporary periods of drought that plague this region. To remedy this situation, many farmers subsoil annually to temporarily eliminate this root-restricting layer. Most farmers routinely choose their tillage depth as the maximum possible with their equipment and tractor. If the depth of tillage chosen is too deep, energy will be wasted and surface residue will be covered. If the depth of tillage chosen is too shallow, tillage may be inadequate to remove the root-restricting layer and thus, all energy used for this tillage operation is wasted. Site-specific measurements of hardpan depth taken in several locations in the Southeastern U.S. indicate that between 25 and 75% of tillage energy could be saved if some form of site-specific tillage could be developed and used (Fulton *et al.*, 1996; Raper, 1999). Also, some data indicate that tillage deeper than necessary may reduce yields (Raper *et al.*, 2000a; Raper *et al.*, 2000b). Therefore, it is important to determine the depth of the root-impeding layer and to till only deep enough to eliminate this layer of soil compaction. A variable-depth tillage (site-specific tillage) system is needed that considers the crop's needs and the soil's variability.

Methods and Materials

In 1999, the first steps were taken to determine the variability found in a 20-acre field at the Alabama Experiment Station's E.V. Smith Research Station in Shorter, AL. This field was selected due to its high level of soil compaction as well as an extreme amount of yield variability. This field contained a Coastal Plain soil, Toccoa fine sandy loam. A set of bulk soil electrical conductivity measurements was obtained with the Veris Technologies electrical conductivity sensor to determine if subsurface differences in soil could be present at the site. Secondly, a complete set of cone penetrometer measurements (ASAE, 1999a; ASAE, 1999b) were obtained with the Multiple-Probe Soil Measurement System (Raper et al., 1999) on an approximate 100 yd grid. Cone index measurements were analyzed for differences in the depth to hardpan over the entire field. Thirdly, a corn crop was planted over the entire field in 1999 and a yield monitor used to harvest the corn. The yield variation data were then used along with the electrical conductivity data and the cone index data to locate the experiment plots.

The cone index data indicated that the depth of soil compaction ranged from 6-18 in. over the entire field. This range of depth of compaction was split into three distinct hardpan depth ranges of 6-10 in., 10-14 in., and 14-18 in., which were replicated four times within the field. Three tillage treatments were imposed within each of the test plots in the spring of 2000, 2001, and 2002:

1. zero tillage (no-till)
2. site-specific tillage (10 in., 14 in., or 18 in. depth tillage)
3. 18 in depth tillage (deep tillage)

For example, in the plots with the shallowest hardpan (the 6-10 in hardpan depth), the site-specific tillage depth was selected to be 10 in. Therefore, three tillage treatments were applied in these shallow hardpan areas; (1) no-tillage, (2) site-specific tillage with a depth of 10 in., and (3) 18-in. depth tillage. The site-specific tillage was adjusted to match the depth of the hardpan previously measured with a soil cone penetrometer for each one of the plots.

Site-specific subsoiling and deep subsoiling were conducted with a JD 955 Row Crop Ripper equipped with 2.75-in. wide LASERRIP™ Ripper Points. This subsoiler was supplied to the NSDL as part of a Cooperative Research and Development Agreement with Deere & Co. Modifications were made to this implement to allow for tillage depth of 6-18 in. and to incorporate heavy residue handling attachments which were supplied by Yetter. This subsoiler was manually adjusted to the necessary tillage depth by moving the coulters and the residue handling attachments up and down on the toolbar.

The JD 955 implement was mounted on a three-dimensional dynamometer supplied by the USDA-ARS National Soil Dynamics Laboratory in Auburn, AL. This device measured draft, vertical, and side forces required for tillage for each plot. A radar gun was used to obtain tillage speed which was used along with the mean draft data to obtain horsepower necessary for tillage.

The first tillage in the plots was conducted in Spring of 2000. The field was split into two halves (Field 1 and Field 2) to allow for a corn-cotton rotation. Cotton was planted in 40 in. rows with 4-row equipment while corn was planted in 30-in rows with 6-row equipment. Plot size was either 4 rows x 100 ft. for cotton or 6 rows x 100 ft. for corn. Half of each plot was planted in a cover crop and the other half was left bare. Prior to planting cotton, the cover crop was rye. Prior to planting corn, the cover crop was crimson clover.

A cotton yield monitor purchased from Zycom (renamed Agriplan) was used to obtain cotton yield data for each of the plots. The yield data obtained over the middle 2-row section for each plot were averaged to determine a mean value for each plot.

A split plot arrangement with four replications with main plots of cover crop and subplots of tillage treatment was analyzed with an appropriate ANOVA model using SAS. A predetermined significance level of $P \leq 0.1$ was chosen to separate treatment effects.

Results and Discussion

Discussions will be limited to main treatment effects although some slight interactions between depth of hardpan, tillage treatment, cover crops, and years were found.

Cotton lint yield averaged across replications, depth of hardpan, and cover crop for years 2000-2002 showed that site-specific tillage had yields equivalent to those plots that received deep tillage (Figure 1). Site-specific tillage (673 lb/ac) and deep tillage (708 lb/ac) both had yields which were greater than no-tillage (626 lb/ac) due to the yield-limiting soil compaction that was present in the Coastal Plain soil found in the experimental field.

When the cotton lint yield data were averaged across replications, depth of hardpan, and tillage treatments for years 2000-2002, a difference in the effect of the cover crop was found (Figure 2). Slightly larger yields (6 %) were found for those plots that received the rye cover crop (690 lb/ac) as compared to those plots that didn't receive any cover crop (648 lb/ac).

The power necessary for tillage showed definite benefits of site-specific tillage (77 hp) as compared to uniform deep tillage (105 hp; Figure 3). Reducing tillage depth from 18 in. to the site-specific depth of tillage necessary to disrupt the compacted layer decreased the tillage power by 27%.

Conclusions

1. Site-specific tillage produced cotton lint yields equivalent to those produced by uniform deep tillage.
2. Cover crops increased cotton lint yield by 6 %.
3. Site-specific tillage reduced tillage power necessary for subsoiling by 27 % compared to uniform deep tillage of 18in.

Disclaimer

The use of trade names or company names does not imply endorsement by USDA-ARS, Auburn University, or the University of Illinois.

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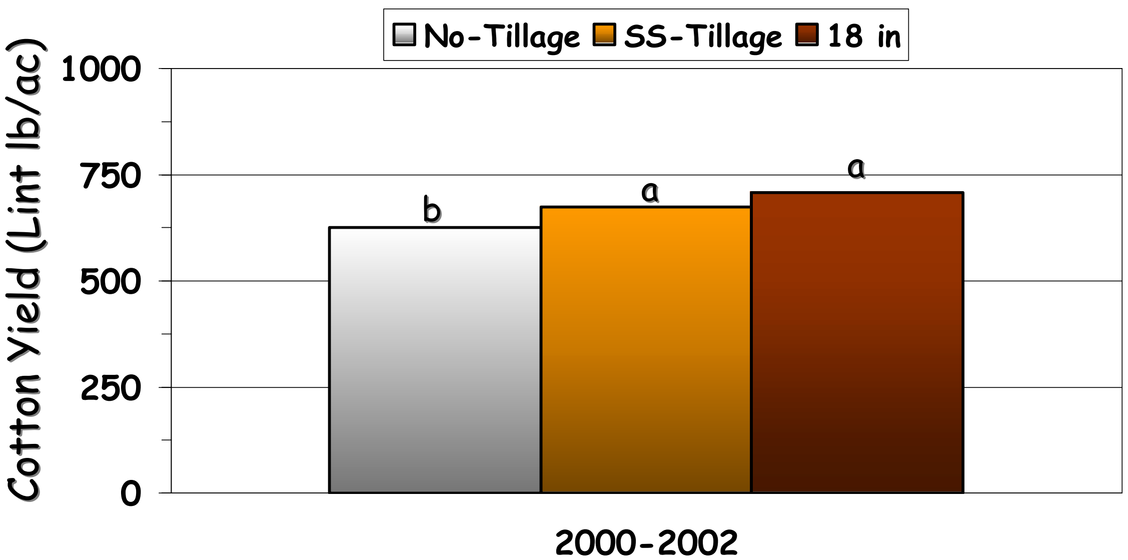

Figure 1. Cotton lint yield averaged over all replications and treatments for years 2000-2002. Letters indicate statistical difference at the 0.1 level.

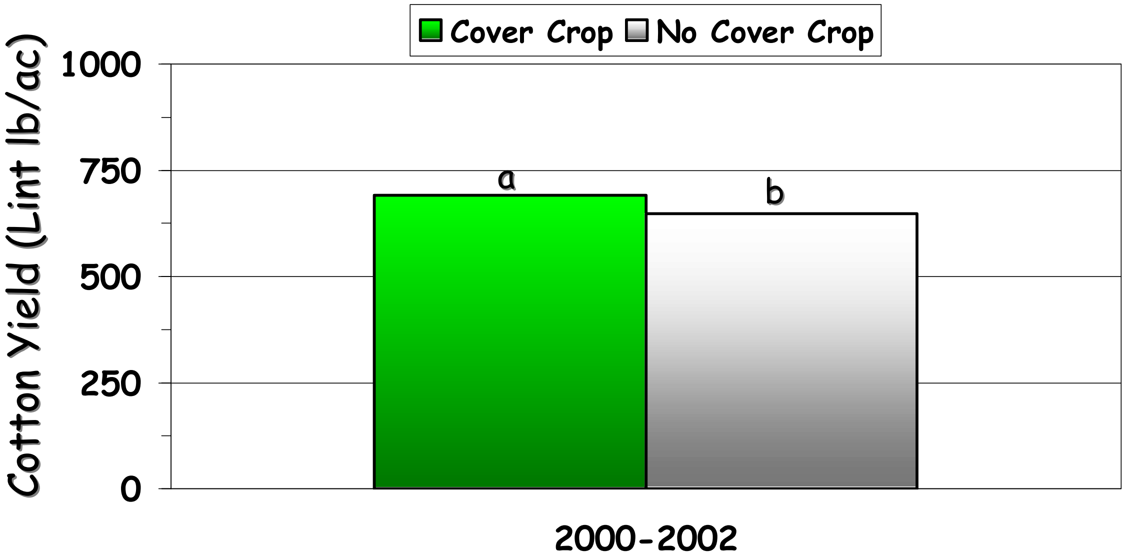

Figure 2. Cotton lint yield averaged over all replications and treatments for years 2000-2002. Letters indicate statistical difference at 0.1 level.

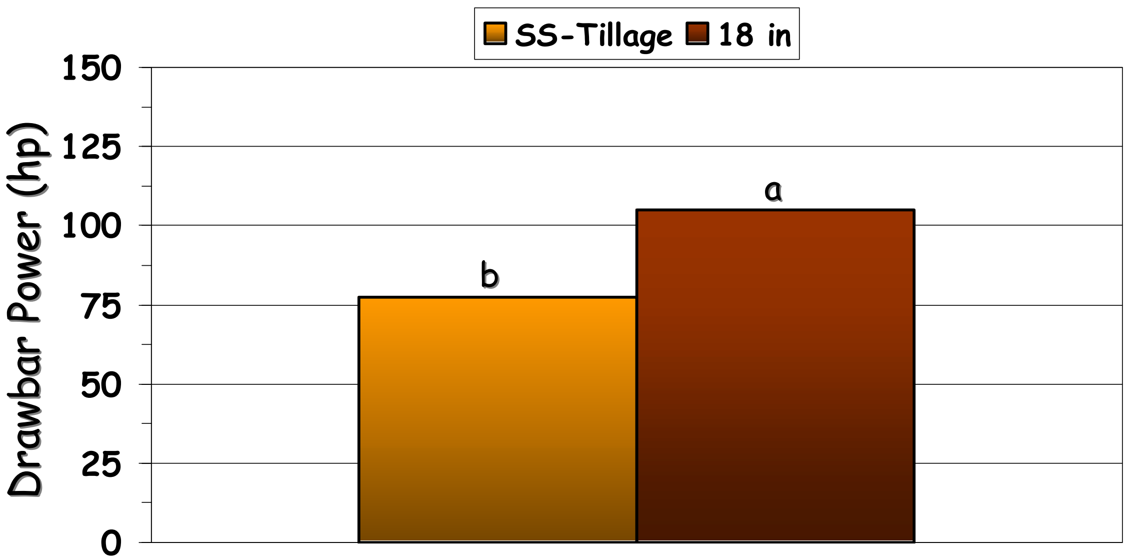

Figure 3. Drawbar power averaged over all replications and treatments for years 2000-2002. Letters indicate statistical difference at 0.1 level.